other investigators will be attracted to the field which he has opened up. The results can not fail to be of direct practical importance as well as of immense scientific value.

At the end of the book is a full explanatory list of notation in English and Ido. The mechanical execution of the work conforms to the usual high standard of the Cambridge University Press.

METEOROLOGY ON CAPTAIN AMUNDSEN'S PRESENT ARCTIC EXPEDITION.

By H. U. SVERDRUP, in charge of the scientific work.

Captain Amundsen's expedition left Norway in July, 1918. The plan was to follow the coast of Siberia eastward to the vicinity of Bering Strait, thence proceed to the north and let the vessel, the *Maud*, especially built for this expedition, freeze in. The vessel was then to be carried with the drifting ice fields across the Arctic Sea until it was released from the grip of the ice between Spitzbergen and Greenland, where the ice masses from the Arctic are slowly drifting south to the Atlantic Ocean. The main object of the expedition was to study the physical conditions of the Arctic Sea by determining depths, temperatures, salinities, and currents. But along with the oceanographical work, a number of other observations, mostly of geophysical interest, were to be carried out, as, for instance, meteorological observations which were to be extended to the upper air by means of pilot balloons and kites, observations of solar and nocturnal radiation, of the temperature distribution in the ice, and magnetic observations in cooperation with the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. However, the ice conditions forced the expedition to winter three times in different places on the coast of Siberia, and in the summer of 1921, the *Maud* had to be sailed to Seattle for repairs.

The first wintering took place close to Cape Chelyuskin, the north point of the Continent. During the sea voyage, the pressure of the air had been registered continuously, and temperature, wind, and cloudiness had been noted six times a day. Shortly after the *Maud* was frozen fast in the vicinity of Cape Chelyuskin, a meteorological hut, containing thermograph, hygrograph, thermometers, and hygrometer was placed on the ice at a distance of about 50 meters from the vessel, and an anemograph was placed on board on the main boom, with the cups 3.5 meters above the roof of the deck's hut.

The meteorological registration for this winter showed several characteristic features. Especially were the frequent storms in the months October to January of interest, because barometric pressure, wind, and temperature always changed in a similar way during the development of the storm. Falling barometer was accompanied by a southwest gale, which might reach a velocity of 50 miles per hour, and by rising temperature, but at the moment the barometer stopped falling, the wind changed abruptly to northeast, and the temperature dropped as much as 20° C. in a few hours. This change of the meteorological elements when a storm passes is similar to the one experienced here when a cold wave passes a place, but the wind directions are here different. The wind directions noted by us indicate that the progression of the cold waves in high latitudes takes place from northeast to southwest, at right angles to the direction of progress in this latitude.

As soon as the daylight returned after the dark season, every opportunity was used for sending up pilot balloons and kites. However, the wind conditions were generally not favorable for kite flights, so the results were not in proportion to the time devoted to the work, but the few successful flights showed clearly the great temperature inversion which, in the winter, is found in the lower strata of the atmosphere in the Arctic. Attempts to send up captive balloons on calm days failed, partly because the rubber balloons to be used for this purpose were too old, having been procured in 1913, partly because we had no means to overcome the difficulties arising from the low temperatures. In May and June, the work with pilot balloons and kites had to be abandoned, because the time had to be devoted to a survey of the most northerly peninsula of the Continent.

The ice held us bound for a whole year, less one day, at Cape Chelyuskin. When we left Captain Amundsen hoped to succeed in beginning the drift. He wanted, however, to send the scientific observations home, to prevent their loss in case the vessel was crushed by the ice. They were, therefore, entrusted to two men, who were to bring them to the nearest settlement, the Russian wireless station at Dickson Island, about 600 miles to the southwest. Along the coast, which they were to follow, three caches with provisions had been left by former expeditions. The plan seemed safe, but unexpected events happened. Captain Amundsen did not succeed in beginning the drift, and the *Maud* reached Nome safely in July, 1920, but the two men who carried our observations lost their lives. With them all the meteorological registrations, together with registrations of the magnetic declination and the tides, were lost, but copies of the meteorological observations made three times daily, at 8 a. m., 2 p. m., and 8 p. m., L. M. T., and of the results of pilot-balloon ascents and kite flights, had fortunately been made and kept on board the vessel.

In September, 1919, when the *Maud* proceeded to the east, the ice conditions were still more unfavorable than in the summer of 1918. Every attempt to penetrate to the north was frustrated, and at the end of the month there was nothing left but to seek a new place for winter quarters on the coast. Thus it happened that the *Maud*, in the winter of 1919–20, was frozen in about 700 miles west of Bering Strait at the island of Ayon. When we stopped there, the island was inhabited by natives of the Siberian tribe known as the Chukchi, who, in a short time, would leave the coast and follow their herds of domesticated reindeer to the inland, where they were accustomed to spend the winter. Captain Amundsen realized that here we had a unique opportunity to study the habits and customs of this little-known tribe, and therefore suggested that I join the natives, accompany them to the interior and return to the ship in the spring. I left the *Maud* in the beginning of October, 1919, and found her in the same place when I returned in May, 1920, after having spent seven and one-half months alone among the Chukchi. Besides having gathered information and made collections of ethnological interest, I had taken meteorological observations usually three times a day, and had secured magnetic observations from five stations in an inaccessible part of the country. On board the *Maud* the registrations of the meteorological elements had been kept up continuously, and the daily observations taken regularly.

In July, 1920, the *Maud* was released from the ice, and Captain Amundsen proceeded to Nome where he had decided to call in order to take on board additional equipment for the drift. After a short stay in Nome, the ex-

pedition left on August 8 with the intention, if possible, of penetrating to the north and beginning the drift. But now the ice hardly permitted us to get inside the Bering Strait. Eighty miles from the strait, at Cape Serdze Kamen, the *Maud* was closed in and had to winter for the third time. During this winter the meteorological registrations and observations were kept up to the same extent as during the preceding winter.

A comparison, particularly between the development of a storm in the vicinity of Bering Strait and at Cape Chelyuskin, discloses several interesting facts. At Bering Strait, falling barometer in the winter is accompanied by southeast wind and rising temperature, but rising barometer is accompanied by northwest wind and falling temperature. This change of the meteorological elements corresponds to the one experienced here when a cold wave passes a place, which indicates that the direction of progress of the cold waves at Bering Strait is approximately the same as here, namely, from northwest to southeast, and not as at Cape Chelyuskin, from northeast to southwest.

Along the coast of the Chukotsk Peninsula, the weather has an extremely local character due to the topographic features of the land. The weather may be fair, with only a light wind along part of the coast, but, for example, in a valley running parallel to the general wind direction, a blizzard may be raging. The wind blows as from a funnel, whirling the snow up and even carrying pebbles and small stones along. At the border of such a local blizzard we once had opportunity to observe some very interesting eddies with vertical axes similar to small tornadoes, which were made visible by the drifting snow. We saw whirling cylinders of snow with a diameter from 2 to 12 meters and a height of about 8 meters. These cylinders, which rotated counterclockwise, moved comparatively slowly in the direction of the wind. These eddies must be quite common under the conditions mentioned, because the natives use a particular name for them. They probably are common at the border of any local air current, but they are not frequently made visible by drifting snow.

The following may illustrate the frequency of storms at the coast. From February to April, 1921, two of us traveled with dog sledges along the coast in order to take magnetic and meteorological observations and gather information of ethnologic interest. We covered about 1,200 miles in 69 days, but on 23 of these we could not proceed on account of blizzards, even though we traveled several times on days when the natives refused to leave the tents. The short distance to the open water in Bering Sea is certainly responsible for the unsettled character of the weather at this coast.

In May and June a number of pilot balloons were sent up. The new balloons we had received in Nome in 1920 through the courteous assistance of the United States Weather Bureau proved to be very satisfactory, so that altitudes between 10 and 15 kilometers were frequently reached.

All the meteorological registrations and observations from the three years, 1918 to 1921, have been forwarded to the Norwegian Meteorological Institution in Christiana, where they will be reduced and published. At present no copy of the observations is available to me, so I have to confine myself to this brief summary regarding the observations made.

Captain Amundsen's expedition is starting out again from Seattle at the beginning of June next. His plans are unchanged; he intends to go from Bering Strait to the north and drift with the ice fields across the Arctic Sea. During the drift barometric pressure, temperature, humidity, and wind are to be registered continuously, and the registrations to be checked by three daily observations. We may also observe the temperature at the top of the mainmast, 30 meters above the deck, by means of a resistance thermometer. For investigation of the upper air currents we have 1,000 pilot balloons, for which the hydrogen has to be developed on board by means of CaH_2 and water. Whether we shall be able to get any results from the pilot balloons during the dark season or not is doubtful. We have a supply of small transparent paper lanterns with candles to be attached to the balloons, but the range of visibility for these lanterns may be too small to give satisfactory results. Furthermore, the expedition has a kite reel and 18 kites, four of which, through the courtesy of the United States Weather Bureau lent the expedition to replace some which were damaged at Cape Chelyuskin. The characteristics of the wind over the Arctic Sea, particularly the change of the wind with altitude, are too little known to permit any opinion as to the successful use of kites. These winds may, however, be more favorable than they are close to the coast. The expedition is also to carry airplanes to be used for geographical exploration, starting from and returning to the ship. During these flights meteorological observations may be carried out.

The most important addition to the equipment of the expedition is a wireless transmitter which will make it possible for us to send daily weather reports. We hope to be able to communicate with Nome during the first part of the drift, and with Spitzbergen during the last part. Whether the daily weather reports from the central Arctic regions will be of value for the weather forecasts in the Temperate Zone is an open question, but they will certainly be of great meteorological interest.